

Clustering of Five Sweet Tamarind Based on Fruit Characteristic

Fitriana Nasution ^{1,2)} and Chinawat Yapwattanaphun ^{1*)}

¹⁾ Department of Horticulture, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand

²⁾ Indonesian Tropical Fruit Research Institute

Indonesian Agency of Agricultural Research and Development

^{*)} Corresponding author Email: agrcw@ku.ac.th

Received: March 23, 2016/ Accepted: June 9, 2016

ABSTRACT

Morphological and genetic characterization of tamarind are useful and important for breeding, commercialization and gene bank management. The cultivars characterized in this study were Intapalum, Sritong, Prakaitong, Khantee and Srichompoo. The comparison of five sweet tamarind cultivars were carried out using ANOVA and DMRT with 0.05 of significant levels. The relationship between morphological characteristics was calculated by the Pearson's correlation coefficient. Phylogenetic analysis used NTSYSpc ver. 2.1 to generate a dendrogram of fruit characters. The quantitative characters (pod weight, pod diameter, and pod length) were significantly different. The biggest fruit was Sritong and the smallest was Khantee. Significant differences were shown on two qualitative characters such as pod shape and flesh color, while there were no significant difference on the seed shape, seed color and skin color. There were positive correlations among all quantitative pod characters of the samples. Pod weight was significantly correlated with pod diameter, however pod length and pod diameter were not significantly correlated. The similarity level from five sweet tamarind cultivars was 44-100 %.

Keywords: clustering; fruit characteristic; sweet tamarind

INTRODUCTION

Tamarind (*Tamarindus indica* L.) has high economic value and it is an important tropical fruit crops. This tree is cultivated by all tropical countries (Verheij & Coronel, 1992). The flesh is used to make some traditional food and beverages because the flesh is highly acidity so it can be combined with sugar, chili and other spices (Singh, Wangchu, & Moond, 2007) and cosmetic (Maenthaisong, Chaiyakunapruk,

Warnnissorn, & Viyoch, 2009). Tamarind is an important tropical fruit tree, however there is only few scholars to study about it (Diallo, Mckey, Chevallier, Joly, & Hossaert-Mckey, 2008).

In 2012, tamarind planting areas were 28,904 ha located in 48 provinces in Thailand (Department of Agricultural Extension Thailand, 2013 in Cuyvers, Assawaphanichkul, Ekasittipol, Laphasuk, & Mhuensai, 2013). According to Komkhuntod, Karintanyakit, Suvittawat, Tanongjid, & Wanichkul (2012), in Thailand, tamarind is identified and divided into 2 groups, namely sweet and sour cultivars. There are more than 50 cultivars of sweet tamarind. Furthermore, the existing seedling tamarind trees offer a wide range of variability for the selection of outstanding types (Challapilli, Chimmad, & Hulamani, 1995). The sweet tamarind tree has unique character due to in the same tree, there is sour fruit occasionally (El-Siddig et al., 2006).

Morphological character is a basic data for taxonomic studies. It is a traditional description and continued in agronomic studies (Babic, Babic, Prodanovic, Filipovic, & Andjelkovic, 2012). Morphological characteristics are genetic tools which useful for breeding, commercialization and gene bank management (Sarkhosh, Zamani, Fatahi, Tabatabaei, & Akrami, 2009; Fatahi, Ebadi, Vezvaei, Zamani, & Ghanadha, 2004; Santos, Pires, & Correa, 2012). The easier characters of fruit components that can be analyzed are fruit size, shape and general appearance (Redalen, 1988). Cervantes & Diego (2010), informed that an aspect of traditional importance in the history of botany is plant shape description. Morphological characteristics were used to distinguish many genera and species of plants, such as the cultivars of *Capsicum annuum* which were classified on the basis of their fruit shapes. However, the morphological characters have some weaknesses, such as the difficulty to identify tribes or subfamilies because some similar characters (Swenson & Anderberg, 2005).

Cite this as: Nasution, F., & Yapwattanaphun, C. (2017). Clustering of five sweet tamarind based on fruit characteristic. *AGRIVITA Journal of Agricultural Science*, 39(1), 38-44. <http://doi.org/10.17503/agrivita.v39i1.857>

Accredited: SK No. 81/DIKTI/Kep/2011

Permalink/DOI: <http://dx.doi.org/10.17503/agrivita.v39i1.857>

Furthermore, information on morphological characteristics of tamarind would be useful partly in promoting the consumption, domestication, protection commercialization and development of the local industries for indigenous fruit trees.

Morphological characteristics can be used to cluster analysis and understand the genetic distance or similarity. Cluster analysis is the most popular for classifying the germplasm and useful information in plant breeding (Kolluru, Rao, Prabhakaran, Selvi, & Mohapatra, 2007; Nemati et al., 2012).

Considering the importance of morphological character data, the characterization and clustering of tamarind cultivars would be carried out in this study and it might be used as a baseline for cultivar selection and breeding programs.

MATERIALS AND METHODS

The study was conducted at laboratory of Kasetsart University, Bangkok, Thailand, in January 2015. The plant materials were five cultivars of sweet tamarind, namely Intapalum, Sritong, Prakaitong, Khantee and Srichompoo. The experiment was conducted by using ten fruit samples with three replications. These cultivars were from Petchabun province, Thailand.

The quantitative and qualitative characters were observed. The size of pod covered weight (g), diameter (cm), length (cm) as quantitative characters. Qualitative characters included skin color, pod shape, seed shape, seed color and flesh color. The skin color, seed color and flesh color were determined by RHS color chart. The pod shape was categorized by three shapes, namely: straight or slightly straight; curved; and curved in "U" shape. The seed shape was categorized by two shapes, namely round and rhomboid.

Comparison of five sweet tamarind cultivars were carried out using ANOVA (Analysis of Variance) and DMRT (Duncan's Multiple Range Test) with 0.05 of significant levels. The Pearson's correlation coefficient was calculated to determine the relationship among morphological characters. Quantitative and qualitative data were converted into binary form, then analyzed in order to build dendrogram tree by using NTSYSpc ver. 2.1 software.

RESULTS AND DISCUSSION

Quantitative characters were taken into consideration for estimating variation and relationship among cultivars. Based on statistical analysis (Table 1), there were variations in pod weight, pod diameter and pod length. The three quantitative characteristics observed were found significantly different among five sweet tamarind cultivars. Sritong had a heaviest pod weight 25.43 g, followed by Intapalum, Prakaitong, Srichompoo and Khantee with 21.72 g, 21.55 g, 18.38 g and 11.50 g, respectively. The widest pod diameter was Prakaitong 2.58 cm, followed by Intapalum, Sritong, Srichompoo and Khantee with 2.51 cm, 2.50 cm, 2.18 cm, and 2.02 cm, respectively. The longest pod was Sritong 11.35 cm, followed by Intapalum, Srichompoo, Prakaitong and Khantee with 11.33 cm, 10.29 cm, 9.78 cm and 8.77 cm, respectively. Similar results were reported by Nandini, Singh, & Dhanapal (2011), who observed that tamarind had some variations on length of pod, weight of pod, width of pod, weight of pulp, weight of seed and number of seed. The analysis was also similar to Okello (2010) who reported that there were significant differences on breadth of pod, mass of pod, total seed number and total seed mass to among varieties on tamarind in Uganda.

Table 1. The value of pod weight, diameter, and length of five sweet tamarind cultivars

Cultivar	Pod weight (g)	Pod diameter (cm)	Pod length (cm)
Intapalum	21.72 ab	2.51 a	11.33 a
Sritong	25.43 a	2.50 a	11.35 a
Prakaitong	21.55 ab	2.58 a	9.78 bc
Khantee	11.50 c	2.02 c	8.77 c
Srichompoo	18.38 b	2.18 b	10.29 ab

Remarks: * = Average in the same row followed by different characters were significantly different at levels of 0.05 by DMRT

The fruit length is one of the important characters because it distinguishes the fruit size as large, medium and small (Zhigila, Abdulrahman, Kolawole, & Oladele, 2014). Khantee was the smallest fruit which had a smaller weight, diameter and length than other cultivars. Similar observation was reported by Suriyapananont (1993), that Khantee had a straight shape and a small sized fruit. The pod was straight and was high in production. The flesh flavor was very

sweet and dark brown color. The biggest fruit was Sritong. Suriyapananont (1993) reported that Sritong had a big size pod, slightly curve and very sweet flavor in the flesh.

There were positive correlations among all quantitative characters of pods among the samples (Table 2). Pod weight was positive and has a significant correlation with pod diameter ($r = 0.895^*$). However, pod length was not significantly correlated with pod weight ($r = 0.862$). Pod length and pod diameter were not significantly correlated ($r = 0.674$). All characters had positive correlations among them. It means that pod weight can be used to assume the pod diameter. Similar results were reported by Challapilli, Chimmad, & Hulamani (1995) who concluded that fruit weight and fruit breadth had positive and significant correlation in tamarind.

Table 2. Pearson's correlation (R) relationship among three quantitative characters

	Pod Diameter	Pod Length
Pod Weight	0.895* (0.040)	0.862 (0.060)
Pod Length	0.674 (0.212)	

Remarks: * = Significant correlation at level of 0.05

There were differences on pod shape and flesh color. However, there were no difference on seed shape, seed color and skin color. The skin color of five cultivars was almost the same. They have grey brown color but with different gradation (grey brown N199C – grey brown N199D) (Table 3).

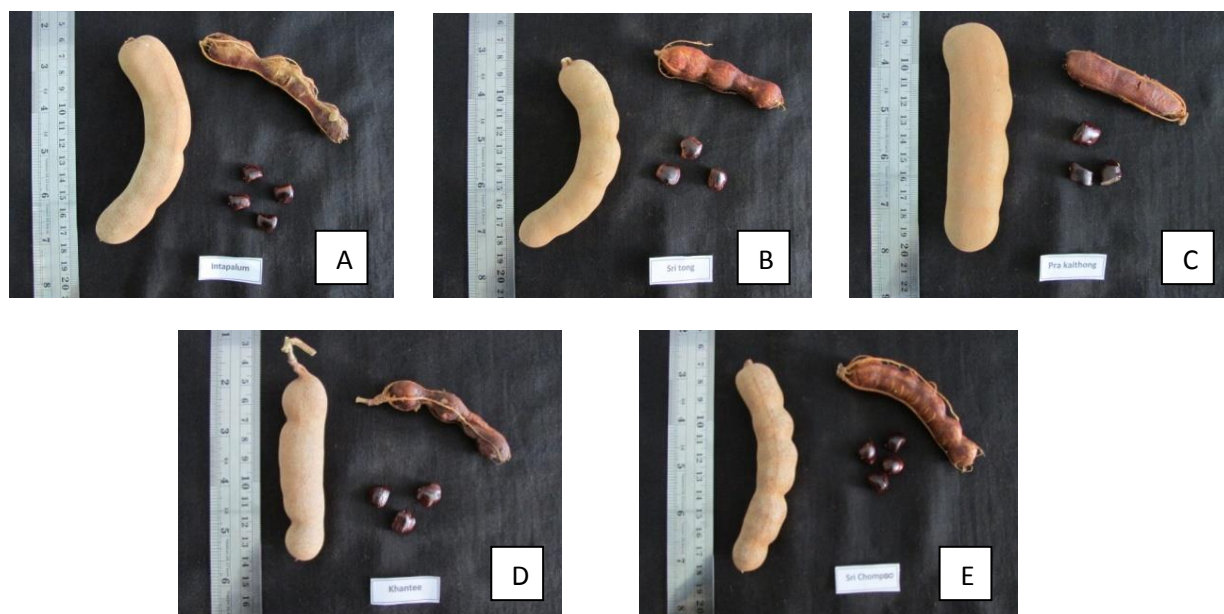
Based on the current study, there were two shapes of pod, namely round curved and round slightly straight (Figure 1). Omuja et al. (2014) reported that the proper design of post harvest machine processing such as handling, sorting and packaging can be easier if it was initiated by the analysis of morphological characters of tamarind fruits. In this research, all seeds shape was rhomboid, due to all cultivars were from sweet tamarind so the seed shape was not different. The seeds were very hard, shiny, reddish or purplish brown.

Evaluation of genetic distance among five sweet tamarind cultivars based on quantitative and qualitative trait is shown in cluster analysis (Figure 2). Grouping based on quantitative and qualitative from five cultivars of sweet tamarind produced visible images of each position of every cultivar in dendrogram. Cluster analysis of five sweet tamarind cultivars based on morphological characters of fruit showed that they had 44-100 % of genetic similarity level.

Based on this cluster, the cultivars which had the greatest genetic similarity (100 %) were Sritong and Intapalum. According to Table 1, Sritong and Intapalum had different value on pod weight but there was no significant difference between them based on statistical analysis. It indicated that they were genetically similar. Among the cultivars that had the smallest genetic similarity (42.9 %) were Srichompoo and Intapalum, Sri Chompoo and Sritong, Srichompoo and Prakaitong. Cluster analysis showed relationship among cultivars (Adeyemi, Gana, & Yusuf, 2011).

Table 3. Qualitative characters of five sweet tamarind cultivars

Cultivar	Skin color	Pod shape	Seed shape	Seed color	Flesh color
Intapalum	Grey Brown N 199 D	Round curved	Rhomboid	Brown 200 B	Brown 200 B
Sritong	Grey Brown N 199 D	Round curved	Rhomboid	Brown 200 A	Brown 200 B
Prakaitong	Grey Brown N 199 D	Round slightly straight	Rhomboid	Brown 200 A	Brown 200 B
Khantee	Grey Brown N 199 C	Round slightly straight	Rhomboid	Brown 200 A	Brown 200 B
Srichompoo	Grey Brown N 199 C	Round curved	Rhomboid	Brown 200 A	Grey orange 166 A



Remarks: A. Intapalum, B. Sritong, C. Prakaitong, D. Khantee, E. Srichompoo
Figure 1. The fruit appearance of five sweet tamarind cultivars

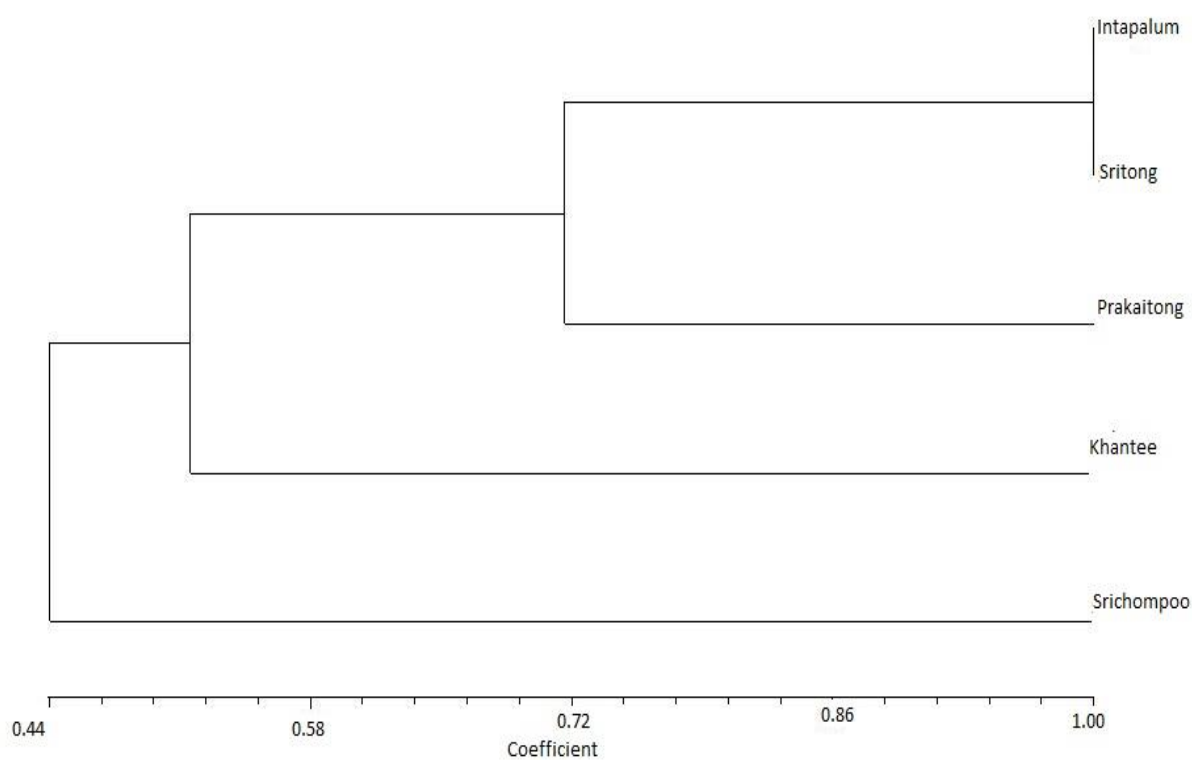


Figure 2. Dendrogram tree showing the clustering of five sweet tamarind cultivars

Genetic diversity is an important aspect in plant breeding program because it is an essential material for parent selection based on parental forms (Bocianowski, Łuczkiwicz, Kozak, & Brzeskwiniewicz, 2008). Therefore, the understanding of genetic distance or genetic similarity is important in the parent selection in breeding. Hence, for the future breeding programs, the genotypes which have the lower genetic similarity can be used as parents (Nandini & Ratan, 2012).

CONCLUSION

Cluster analysis of five sweet tamarind cultivars had 44-100 % of genetic similarity level. The quantitative characters (pod weight, pod diameter and pod length) were significantly different. The biggest fruit was Sritong and the smallest was Khantee. There were differences of pod shape and flesh color. However, there were no differences on seed shape, seed color and skin color. There was a positive correlation among all quantitative characters of pods in the samples. Pod weight was significantly correlated with pod diameter, while pod length and pod diameter were not significantly correlated.

ACKNOWLEDGEMENT

The authors thank to Indonesian Agency of Agricultural Research and Development (IAARD) as sponsorship and funding for this study.

REFERENCES

- Adeyemi, R. A., Gana, A. S., & Yusuf, S. T. (2011). Biometrical character interrelationship and morphological variations in some upland rice (*Oryza sativa* L.) varieties. *African Journal of Food, Agriculture, Nutrition and Development*, 11(2), 4673–4687. Retrieved from <http://www.ajfand.net/Volume11/No2/Adeyemi9505.pdf>
- Babic, M., Babic, V., Prodanovic, S., Filipovic, M., & Andjelkovic, V. (2012). Comparison of morphological and molecular genetic distances of maize inbreds. *Genetika*, 44(1), 119–128. <http://doi.org/10.2298/GENSR1201119B>
- Bocianowski, J., Łuczkiwicz, T., Kozak, M., & Brzeskwiniewicz, H. (2008). Does genetic distance of parental forms affect specific combining ability and heterosis effects in F1 and F2 of spring rape diallel cross? *Agriculturae Conspectus Scientificus*, 73(4), 211–215. Retrieved from <https://acs.agr.hr/acs/index.php/acs/article/download/25/24>
- Cervantes, E., & Diego, J. G. de. (2010). Morphological description of plants: New perspectives in development and evolution. *International Journal of Plant Developmental Biology*, 4(1), 68–71. Retrieved from [http://www.globalsciencebooks.info/Online/GSBOOnline/images/2010/IJPDB_4\(1\)/IJPDB_4\(1\)68-71o.pdf](http://www.globalsciencebooks.info/Online/GSBOOnline/images/2010/IJPDB_4(1)/IJPDB_4(1)68-71o.pdf)
- Challapilli, A. P., Chimmad, V. P., & Hulamani, N. C. (1995). Studies on correlation between some fruit characters in tamarind fruits. *Karnataka Journal of Agricultural Sciences*, 8(1), 114–115. Retrieved from <http://14.139.155.167/test5/index.php/kjass/article/viewFile/5926/6154>
- Cuyvers, L., Assawaphanichkul, O., Ekasittipol, T., Laphasuk, S., & Mhuensai, P. (2013). *Market profile: Thailand's export potentials of tamarinds to the USA*. Bangkok. Retrieved from [https://www.uantwerpen.be/images/uantwerpen/container2626/files/CAS en ASEAN/ASEAN33.pdf](https://www.uantwerpen.be/images/uantwerpen/container2626/files/CAS%20en%20ASEAN/ASEAN33.pdf)
- Diallo, B. O., McKey, D., Chevallier, M. H., Joly, H. I., & Hossaert-McKey, M. (2008). Breeding system and pollination biology of the semi-domesticated fruit tree, *Tamarindus indica* L. (Leguminosae: Caesalpinoideae): Implications for fruit production, selective breeding, and conservation of genetic resources. *African Journal of Biotechnology*, 7(22), 4068–4075. Retrieved from <http://www.scopus.com/inward/record.url?eid=2-s2.0-57149088485&partnerID=40&md5=63cff76eb3ec5da7b001aff3cca104cc>
- El-Siddig, K., Gunesana, H. P. M., Prasad, B. A., Pushpukumara, D. K. N. G., Ramana, K. V. R., Vijayanand, P., & Williams, J. T. (2006). *Fruits for the future 1 – Tamarind (Tamarindus indica L.)* (Revised). Southampton, UK: Southampton Centre for Underutilized Crops.

- Fatahi, R., Ebadi, A., Vezvaei, A., Zamani, Z., & Ghanadha, M. R. (2004). Relationship among quantitative and qualitative characters in 90 grapevine (*Vitis vinifera*) cultivars. *Acta Horticulturae* 640, 275-282. <http://doi.org/10.17660/ActaHortic.2004.640.33>
- Kolluru, R., Rao, A. R., Prabhakaran, V. T., Selvi, A., & Mohapatra, T. (2007). Comparative evaluation of clustering techniques for establishing AFLP based genetic relationship among sugarcane cultivars. *Journal of the Indian Society of Agricultural Statistics*, 61(1), 51-65. Retrieved from <http://www.isas.org.in/jsp/volume/vol61/rameshkolluruscan0002.pdf>
- Komkhuntod, R., Karintanyakit, P., Suvittawat, K., Tanongjid, K., & Wanichkul, K. (2012). Germplasm surveying collection and identification of tamarind (*Tamarindus indica* Linn.) in Thailand. In *Proceedings of 50th Kasetsart University Annual Conference: Agricultural Extension and Home Economics, Plants* (pp. 341-348). Bangkok, TH: Kasetsart University. Retrieved from <https://www.cabdirect.org/cabdirect/abstract/20123323045>
- Maenthaisong, R., Chaiyakunapruk, N., Wamnisom, P., & Viyoch, J. (2009). Cleansing lotion containing tamarind fruit pulp extract. III. Study of lightening efficacy and skin irritation on Asian skin type. *ScienceAsia*, 35(1), 24-30. <http://doi.org/10.2306/scienceasia1513-1874.2009.35.024>
- Nandini, R., & Ratan, T. (2012). Peculiar features, ageless wonders and the complex biodiversity of nallur tamarind heritage site. *Bionano Frontier*, 228-232. Retrieved from <http://bionanofrontier.org/wp-content/uploads/2013/06/SPECIALISSEECOREVOLUTIONAUGUST-2012/60R NANDINI.pdf>
- Nandini, R., Singh, T., & Dhanapal, G. (2011). Morphometric and molecular diversity studies in tamarind (*Tamarindus indica* Linn.) population. *Journal of Plant Molecular Biology & Biotechnology*, 2(2), 26-33. Retrieved from https://www.researchgate.net/profile/Ratan_Telem/publication/229163412_Morphometric_and_Molecular_Diversity_Studies_in_Tamarind_Tamarindus_indica_Linn_populati
- on/links/09e415007869a42c1c000000.pdf?origin=publication_detail
- Nemati, Z., Tehranifar, A., Farsi, M., Kakhki, A. M., Nemati, H., & Khayat, M. (2012). Evaluation of genetic diversity of Iranian pomegranate cultivars using fruit morphological characteristics and AFLP markers. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 40(1), 261-268. Retrieved from <http://profdoc.um.ac.ir/paper-abstract-1029012.html>
- Okello, J. (2010). *Morphological and nutritional characteristics of Tamarindus Indica (LINN) fruits in Uganda*. Unpublished master's thesis, Makerere University, Uganda.
- Omuja, F., Bigirimana, C., Isubikalu, P., Malinga, M., Bizuru, E., Namutebi, A., ... Okullo, J. B. L. (2014). Morphological and physico-chemical characteristics of *Saba comorensis*: A highly preferred Lake Victoria basin indigenous fruit tree in Busia District, Eastern Uganda. *Journal of Medicinal Plants Studies*, 2(2), 127-136. Retrieved from http://www.plantsjournal.com/vol2Issue2/Issue_feb_2014/15.1.pdf
- Redalen, G. (1988). Quality assessment of apple cultivars and selections. *Acta Horticulture* 224, 441-448. <http://doi.org/10.17660/ActaHortic.1988.224.59>
- Santos, R. C., Pires, J. L., & Correa, R. X. (2012). Morphological characterization of leaf, flower, fruit and seed traits among *Brazilian Theobroma* L. species. *Genetic Resources and Crop Evolution*, 59(3), 327-345. <http://doi.org/10.1007/s10722-011-9685-6>
- Sarkhosh, A., Zamani, Z., Fatahi, R., Tabatabaei, S. Z., & Akrami, M. R. (2009). Study on relationships among quantitative and qualitative characteristics of fruit components of pomegranate genotypes. *Acta Horticulturae* 818, 233-238. <http://doi.org/10.17660/ActaHortic.2009.818.34>
- Singh, D., Wangchu, L., & Moond, S. K. (2007). Processed products of tamarind. *Natural Product Radiance*, 6(4), 315-321. Retrieved from [http://nopr.niscair.res.in/bitstream/123456789/7878/1/NPR_6\(4\)_315.321.pdf](http://nopr.niscair.res.in/bitstream/123456789/7878/1/NPR_6(4)_315.321.pdf)
- Suriyapananont, S. (1993). *Identification of tamarind base on isozyme patterns in leaf*. Unpublished master's thesis, Kasetsart

- University, Bangkok.
- Swenson, U., & Anderberg, A. A. (2005). Phylogeny, character evolution, and classification of Sapotaceae (Ericales). *Cladistics*, 21(2), 101–130. <http://doi.org/10.1111/j.1096-0031.2005.00056.x>
- Verheij, E. W. M. & Coronel, R. E. (1992). *Plant resources of South-East Asia*. No. 2, *Edible fruits and nuts*. Wageningen, Netherlands: Pudoc.
- Zhigila, D. A., Abdulrahman, A. A., Kolawole, O. S., & Oladele, F. A. (2014). Fruit morphology as taxonomic features in five varieties of *Capsicum annuum* L. Solanaceae. *Journal of Botany*, 2014, 1–6. <http://doi.org/10.1155/2014/540868>